

GE Renewable Energy

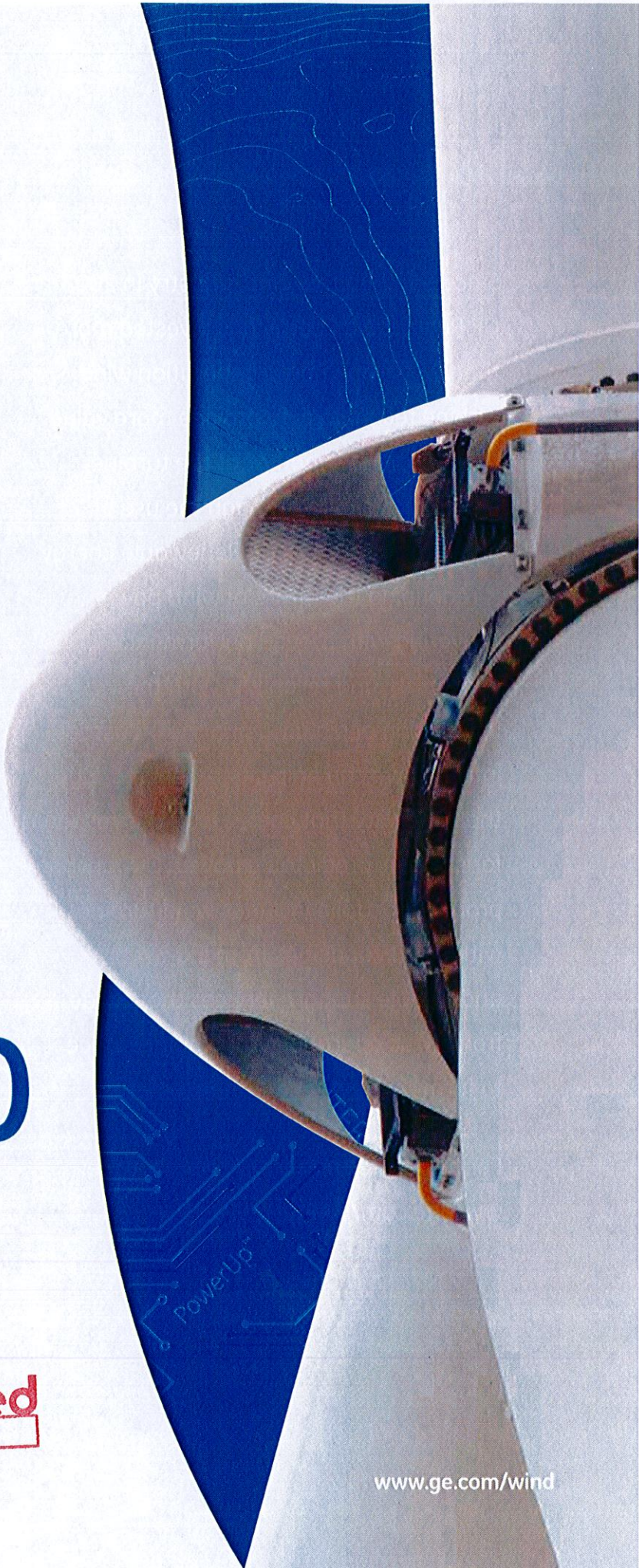
BEST-IN-CLASS
CAPACITY FACTOR

GE's
1.7-100



received
4-12-16

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Since entering the wind industry in 2002, GE Renewable Energy has invested more than \$2 billion in next-generation wind turbine technology to provide more value to customers—whether at the turbine, plant or grid level. Through the use of advanced analytics, GE Renewable Energy is redefining the future of wind power, delivering with proven performance, availability and reliability. With the integration of big data and the industrial internet, we can help customers manage the variability that comes with this resource for smooth, predictable power. Our onshore product portfolio includes wind turbines with rated capacities from 1.6-3.4 MW and flexible support services that range from basic operations and maintenance to farm- or fleet-level enhancements.

For more information visit our website:
www.ge.com/wind

GE's 1.7-100 Wind Turbine

GE's 1.7-100 wind turbine offers a 47% increase in swept area when compared to the 1.6-82.5 turbine, resulting in a 24% increase in Annual Energy Production (AEP) at 7.5 m/s. This increase in blade swept area allows greater energy capture and improved project economics for wind developers. GE's 1.7-100 turbine has a 53% gross capacity factor at 7.5 m/s—a class leading performance. GE's proprietary 48.7 meter blade uses the same proven aerodynamic shape as the blades found on the 2.x-100 fleet.

GE's stringent engineering procedures result in a turbine made for high performance, reliability and availability. The use of the rotor from the proven GE 2.x-100 turbine and selected component modifications provide increased annual production with the same reliable performance as the 1.5 MW series turbine.

GE's 1.7-100 meter wind turbine advances the 1.6-100 wind turbine series by utilizing electrical system upgrades to increase the rating from 1.6 MW to 1.7 MW, allowing higher energy production while maintaining consistent workhorse performance, reliability and efficiency.

Available in 80-meter and 96-meter hub heights, these sizes provide flexible options for Class III wind sites, allowing for higher energy capture in lower wind speed environments.

Building Upon the Proven 1.5 MW and 2.5 MW Platforms

The evolution of GE's 1.5 MW turbine began with the 1.5i turbine introduced in 1996. The 65-meter rotor was increased to 70.5-meters in the 1.5s then to 77-meters in the 1.5sle turbine which was introduced in 2004. Building on the exceptional performance and reliability of the 1.5sle, GE introduced the 1.5xle with its 82.5-meter diameter in 2005. Subsequent improvements led to the 1.6-82.5 turbine, introduced in 2008. Ongoing investment in the industry workhorse resulted in the introduction of GE's 1.6-100, and now the 1.7-100 wind turbine with a 100-meter rotor. This product evolution provides an increased capacity factor while increasing AEP by 20–24%.

Incremental changes to the 1.6-100 and 1.7-100 have resulted in significant performance enhancements which include: greater blade length, controls improvements and enhanced power conversion capabilities resulting in increased AEP. With high-reliability to ensure continued operation in the field, GE's 1.7-100 can provide excellent availability comparable with the 1.5 MW series units operating in the field today.

Technical Description

GE's 1.7-100 wind turbine is a three-blade, upwind, horizontal axis wind turbine with a rotor diameter of 100-meters. The turbine rotor and nacelle are mounted on top of a tubular steel tower providing hub heights of 80-meters and 96-meters. The machine uses active yaw control to keep the rotor pointed into the wind. The turbine can operate at a variable speed and uses a doubly fed asynchronous generator with a partial power conversion system.

Specifications:

1.7-100 Wind Turbine:

- Engineered to IEC 61400-1
- Standard and cold weather extreme options
- Standard tower corrosion protection; C2 internal and C3 external with optional C4 internal and C5 external available
- Rotational direction: Clockwise viewed from an upwind location
- Speed regulation: Electric drive pitch control with battery backup
- Aerodynamic brake: Full feathering of blade pitch

Features and Benefits

- Higher AEP than its 1.6 MW predecessors
- Highest capacity factor in its class
- Engineered to meet or exceed the 1.5 MW platform's historic high availability
- Grid friendly options are available:
 - Enhanced Reactive Power, Voltage Ride Thru, Power Factor Control
- Wind Farm Control System; WindSCADA*
- GE proprietary 48.7 meter blade
- Available in both 50 Hz and 60 Hz versions for global suitability

Construction

Towers: tubular steel sections provide hub heights of 80-meters or 96-meters

Blades: GE 48.7-meter blades

Drivetrain components: GE's 1.7-100 uses proven gearboxes, mainshaft and generators with appropriate improvements to enable the larger rotor diameter on the 1.7 MW machine

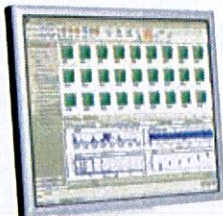
Enhanced Controls Technology

The 1.7-100 wind turbine employs enhanced control features:

- GE's patented Advanced Loads Control reduces loads on turbine components by measuring stresses and individually adjusting blade pitch
- Controls developed by GE Global Research to minimize loads including those at near rated wind speeds to improve Annual Energy Production (AEP)

Condition Monitoring System (option)

GE's Condition Monitoring System* (CMS) and SCADA Anomaly Detection Services, a complementary suite of advanced condition monitoring solutions, proactively detect impending drive train and whole-turbine issues enabling increased availability and decreased maintenance expenses. Built upon half a century of power generation drivetrain and data anomaly monitoring experience, this service solution is available as an option on new GE Units and as an upgrade.



Construction

Lower tubular steel sections provide hub heights of 80 meters or less.

Blades: GE 48-footer blades

Generator components: GE's 3.7-100 uses proven generator, power transformer and generator with appropriate improvements to enable the largest capacity on the 1.7-MW machine.

Enhanced Control Technology

The 1.7-100 wind turbine employs enhanced control technology.

GE's patented Advanced Load Control reduces loads on turbine components by responding to gusts and intelligently adjusting blade pitch.

Control is supported by GE Global Services, a global service and maintenance organization that provides a full range of services to ensure maximum uptime and performance.

BEST-IN-CLASS CAPACITY FACTOR



MAKING RENEWABLES THE ENERGY OF CHOICE FOR A CLEANER FUTURE

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GE Renewable Energy

GE's 2MW Platform

A CUSTOMIZABLE
PLATFORM TO ENHANCE
SITING EFFICIENCY



received
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GE'S 2MW PLATFORM

Since entering the wind industry in 2002, GE Renewable Energy has invested more than \$2 billion in next-generation wind turbine technology to provide more value to customers—whether at the turbine, plant or grid level. Through the use of advanced analytics, GE Renewable Energy is redefining the future of wind power, delivering with proven performance, availability and reliability. With the integration of big data and the industrial internet, we can help customers manage the variability that comes with this resource for smooth, predictable power. Our onshore product portfolio includes wind turbines with rated capacities from 1.6-3.4 MW and flexible support services that range from basic operations and maintenance to farm- or fleet-level enhancements.

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2.0-2.4 MW Platform

GE's 2.2-2.4MW, 107m rotor wind turbine is an advanced evolution of the 1.x series, providing an up to 35% increase in Annual Energy Production (AEP) over its predecessor, the 1.85-87 (at a 2.4 rating). Configured for medium wind speeds, the 2.2-2.4MW turbine provides a 51% increase in swept area with the 107-meter rotor, and an extra 350-450 kW output at rated wind speed compared to the 1.85-87 turbine, improving project economics for wind developers. GE's proprietary Advanced Loads Control combines drivetrain sensors with Mark* V1e turbine controller capabilities to individually pitch the blades and improve load handling performance.

GE's 2.0-2.3MW, 116-meter rotor wind turbine offers a 27% increase in swept area when compared to the 1.7-103 turbine, resulting in an up to 26% increase in Annual Energy Production (AEP) at 7.5 m/s (at a 2.3 rating). This increase in blade swept area allows greater energy capture and improved project economics for wind developers[†]. GE's 2.0-116 turbine has a 53.3% gross capacity factor at 7.5 m/s, a class leading performance. GE's proprietary 56.9-meter blade is specifically for the 2.0-2.3MW rating of this platform, enabling longer length, lower loads and improved performance.

GE's stringent procedures result in a turbine engineered for high performance and availability. The use of selected components from both the 1.x and 2.x platforms ensures the consistent workhorse performance and reliability that GE wind turbines are known for. The 2.0-2.4MW platform utilizes the same drivetrain and electrical system architecture as GE's 1.x series, with both systems scaled and upgraded to provide improved performance along with greater wind turbine energy production. Other critical components have been scaled from the existing platforms to meet the specific technical requirements of this evolutionary turbine.

Ensuring consistent performance, reliability and efficiency, GE's new 2.0-2.4MW platform of wind turbines is an advanced evolution of the 1.x platform series, scaling and developing 1.x platform electrical system upgrades to increase the rating of the turbine from 1.7 MW to range from 2.0-2.4 MW, allowing higher energy production.

[†] Comparative statements refer to GE technology unless otherwise stated.

Building Upon the Proven 1.x and 2.x Platforms

The evolution of GE's 1.5 MW turbine began with the 1.5i turbine introduced in 1996. The 65-meter rotor diameter turbine soon was increased to 70.5-meters in the 1.5s, then to 77-meters in the 1.5sle turbine that was introduced in 2004. Building on the exceptional performance and reliability of the 1.5sle, GE introduced the 1.5xle with its 82.5-meter diameter in 2005. Subsequent improvements led to the introduction of the 1.6-82.5 turbine in 2008—followed by the 1.6-87 in 2011, and ultimately the 1.85-82.5 and 1.85-87 in 2013. Ongoing investment in the industry workhorse resulted in the introduction of GE's 1.6-100 and 1.7-100, wind turbines with a 100-meter rotor. This product evolution provides increased capacity factor while increasing AEP by 20–24% over the previous models. Built from the maturity of its predecessors, the 2.0-2.4MW platform evolution provides increased capacity factor while increasing AEP and application space of GE's 1-2MW platform of products.

Significant component enhancements to the 1.x models have resulted in a substantial performance increase, enabling the use of a 107-meter and 116-meter rotor on the 1.x series, and a nameplate range of 2.0-2.4MW (with applicable rotor). These enhancements include new aerodynamics enabling a greater blade length (116-meter rotor), larger bedplate, generator frame and gearbox, controls improvements, and enhanced power conversion capabilities resulting in an increase in nameplate and AEP. Made for high reliability, GE's 2.0-2.4MW platform can provide excellent availability, comparable with the 1.x series units operating in the field today.

Technical Description

GE's 2.0-2.4MW platform, is a three-blade, upwind, horizontal axis wind turbine with a rotor diameter of either 107 or 116 meters. The turbine rotor and nacelle are mounted on top of a tubular steel tower, providing a hub height of either 80 or 94 meters. The turbine uses active yaw control to keep the blades pointed into the wind. The 2.0-2.4MW platform operates at a variable speed and uses a doubly fed asynchronous generator with a partial power converter system.

Specifications:

- 2.2-2.4MW, 107-meter rotor wind turbine: engineered to IEC 61400-22 ed 3, Class IIS
- 2.0-2.3MW, 116-meter rotor wind turbine: engineered to IEC 61400-22 ed 3, Class IIIS
- Standard and cold weather extreme options
- Standard tower corrosion protection: C2 internal and C3 external with internal and external C4/C5 options available
- Rotational direction: Clockwise viewed from an upwind location
- Speed regulation: Electric drive pitch control with battery backup
- Aerodynamic brake: Full feathering of blade pitch

Features and Benefits

- 2.2-2.4MW, 107-meter rotor: higher AEP than its 1.x predecessors by incorporating a larger gearbox scaled from GE's 2.x platform and longer 52.2-meter blades
- 2.0-2.3MW, 116-meter rotor: GE proprietary 56.9-meter blade; highest capacity factor in its class
- Engineered to meet or exceed the 1.x platform's historic high availability
- Grid friendly options are available
 - Enhanced Reactive Power, Voltage Ride Thru, Power Factor Control
- Wind Farm Control System; WindSCADA*
- Available in both 50 Hz and 60 Hz versions for global suitability

Construction:

Towers: Tubular steel sections provide a hub height of either 80 or 94 meters

Blades: GE 52.2 meter blades (107-meter rotor), and GE 56.9m meter blades (116-meter rotor)

Drivetrain components: GE's 2.0-2.4MW platform uses an enhanced gearbox, main shaft, and generator with appropriate improvements to enable the 107-meter diameter rotor in medium winds, and the 116-meter rotor in lower wind speeds

Enhanced Controls Technology

The 2.0-2.4MW wind turbine products employ enhanced control features including:

- GE's patented Advanced Loads Control reduces loads on turbine components by measuring stresses and individually adjusting blade pitch.
- Controls developed by GE Global Research to reduce extreme loads, including those near rated wind speeds, to improve Annual Energy Production (AEP).

Condition Monitoring System (option)

GE's Condition Monitoring System* (CMS) and SCADA Anomaly Detection Services, a complementary suite of advanced condition monitoring solutions, proactively detect impending drivetrain and whole-turbine issues enabling increased availability and decreased maintenance expenses. Built upon half a century of power generation drivetrain and data anomaly monitoring experience, this service solution is now a standard feature available on GE's 2.0-2.4MW platform, for both rotor types.

A CUSTOMIZABLE PLATFORM TO ENHANCE SITING EFFICIENCY



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DIGITAL WIND FARM

TORQUE

WindSCADA

CONNECTED MACHINES

YAW

INDUSTRIAL INTERNET

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Turbine Signage Example



Project Name

Turbine - #

Emergency 911 Address

Emergency Call 911